Chapter 2

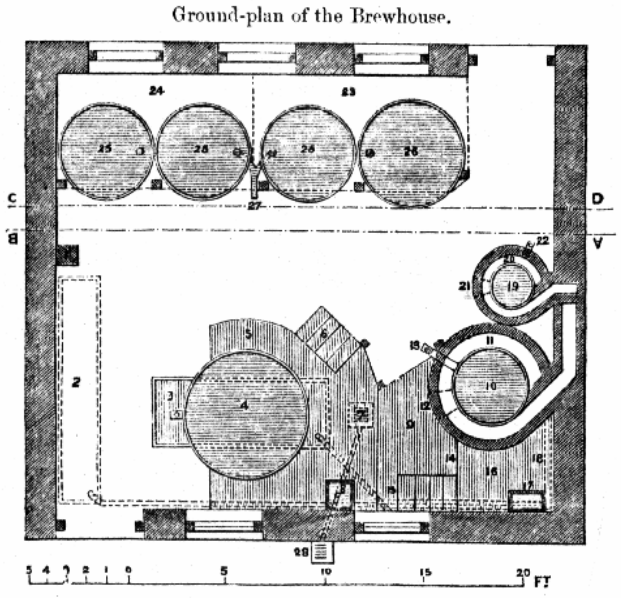
The brewing process in brief

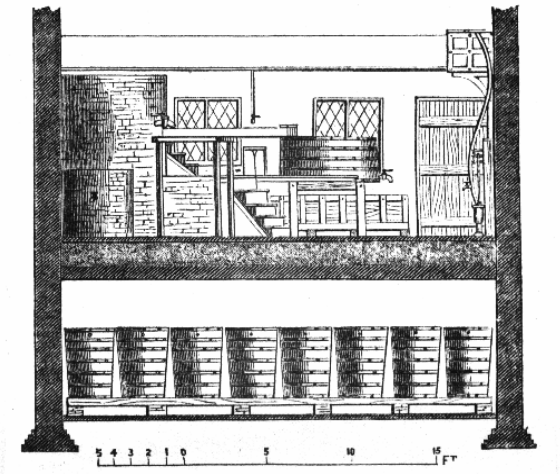
Malt does more than Milton can to justify God's ways to man.
A.E. Housman, A Shropshire Lad, LXII

It is impossible to understand the arrangement and development of the brewery without a general understanding of the brewing process. Although the nineteenth and twentieth centuries saw enormous changes in the machinery and implements used for brewing, the essential process remained much the same as it had for centuries. The following is a simplified description of the steps of commercial brewing as practiced in the United States through the Civil War period; this account cannot present the full detail, variety and evolution of brewing practices and technology during the nineteenth century.

Beer generally consists of four main ingredients: barley malt, hops, yeast and water. Malt supplies the starch that, through mashing, boiling and fermentation, is eventually converted to alcohol. Hops, the flower of a vine of the nettle family, contains a bitter substance which flavors and helps clarify and preserve beer. Water is the main ingredient by weight and volume, of course, and is a necessary medium for the dissolution of the malt starch and for boiling. Brewer's yeast is added after boiling to ferment the beer, that is, to convert its sugars to alcohol and carbon dioxide.

The first operation in the manufacture of beer is *malting*. This process involves the forced germination of barley grains. Germination breaks up the husks of the grain and produces the enzymes diastase and peptase, instrumental in the release and dissolution of the barley starch and its



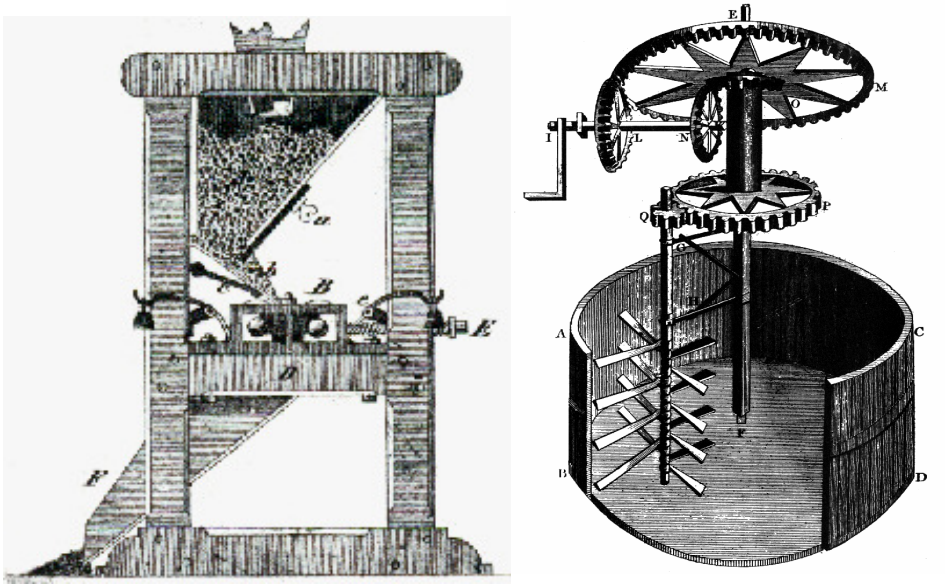


Plans of a small brewery, from John Pitt's How To Brew Good Beer. *Alexandria's breweries of the 1860s were probably arranged similarly.*

breakdown into maltose (malt sugar) during the early stages of the brewing process. As practiced in the mid nineteenth century, barley was normally steeped in wooden tanks of water for 40 to 60 hours. Then the grain was laid several inches deep on a stone malting floor to dry. The drying period varied greatly, although it usually took less than a week. The barley was periodically turned with wooden shovels until it had dried enough to sprout rootlets. At that point, it was necessary to prevent further growth, so it was placed in a drying kiln, then removed and placed into a second kiln in which the drying process was completed and the malt was somewhat roasted. Finally, broken kernels, rootlets, dust, and other foreign matter were sifted out, and the malt was sacked and shipped to the brewery, where it was stored in grain bins or elevators until needed. (H.S. Rich & Co. 1903:58-62; Kearse Publishing Co. 1907:9; Ronnenberg 1993:61)

In general, eighteenth-century brewers did their own malting, but for most of the nineteenth and twentieth centuries brewers purchased malt from independent maltsters. By the end of the 1800s, however, some large breweries and syndicates had vertically integrated, returning to providing their own malt by acquiring or building malt houses. Although the basic process did not change, malting improved greatly after the Civil War. The use of thermometers to monitor floor drying was widespread. New floor materials, steeping casks, drying fans and kilns were invented and brought into common use. By the end of the century, floor malting was largely discontinued in favor of mechanical pneumatic and drum-malting systems. (H.S. Rich & Co. 1903:63-75)

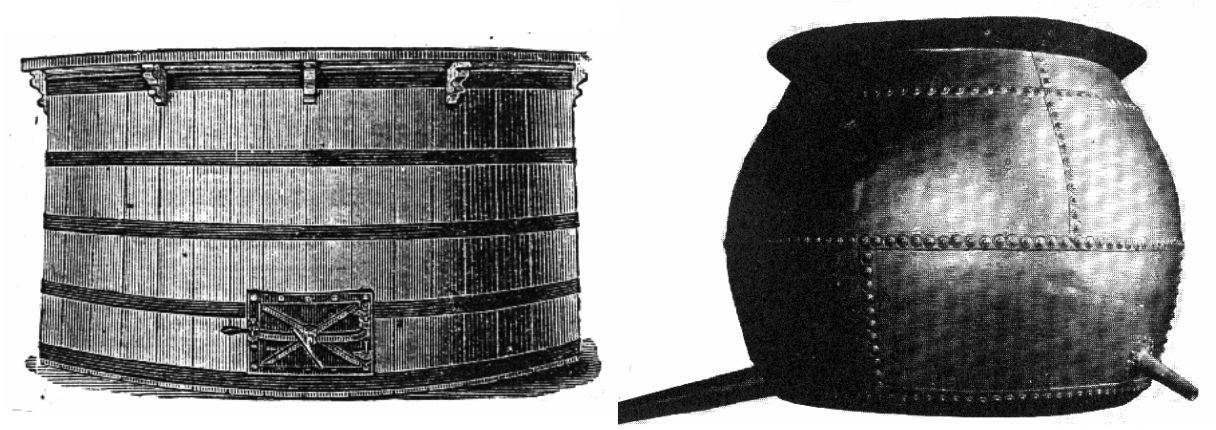
Even in small-scale operations, brewing was arranged to take advantage of gravity, thereby saving labor. Ground malt was typically elevated to hoppers (storage bins) at the highest level of the brewhouse. It was then dropped into a mash tun with water, and from there the resulting liquid, called *wort*, was drained from each vessel to the next lower vessel, as it underwent each stage of



Images of a turn-of-the-nineteenth-century malt mill, left, and a mash tun with agitator, right, from Grundsatze der Bierbrauerei *and* One Hundred Years of Brewing*, respectively.*

preparation. A sale advertisement for a mid-eighteenth-century New Jersey brewery described its operation as "contrived for carrying the Liquor from Place to Place with ease, by the turning of a cock, or taking out of a Plug…" (Baron 1962:49)

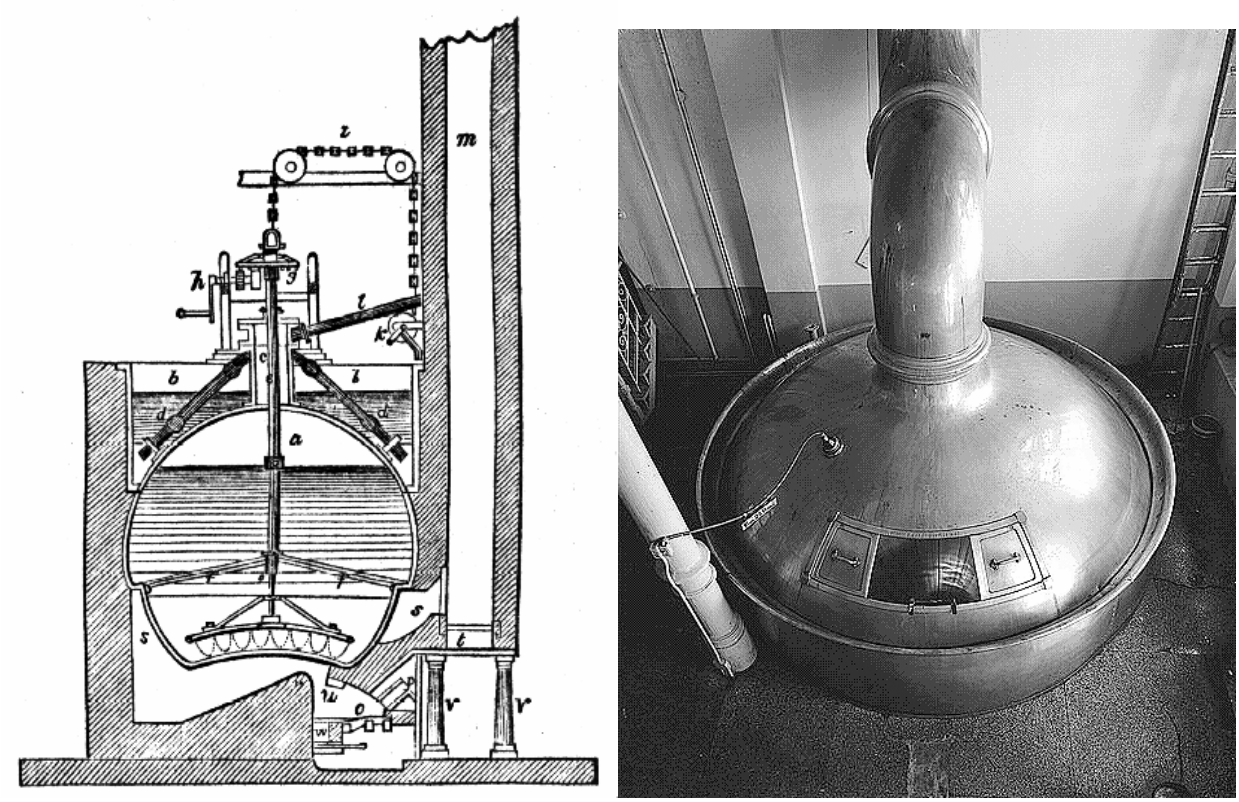
Barley malt was first crushed in a malt mill, then put into the large tub, known as a *mash tun*, for *mashing*. Hot water—between 140 and 190 degrees, depending on the type of beer being made—was pumped into the mash tun, and the mixture was agitated. This stirring helped release the malt's starch from the kernels and broke it down into maltose, a fermentable complex sugar. The earliest method of mashing involved stirring by hand with a large oar. Gear-driven devices for this purpose were first employed in the eighteenth century and could be powered by hand, horse, or steam engine. After the first mash, the resultant liquid *wort* was released into a vessel called the *underback* or into a *brewing kettle*. At this point, hot water, usually five to ten degrees hotter than for the first mash, was added to the same malt in the tun, and it was again agitated. This procedure was usually repeated at least three times in order to extract as much starch as possible. It was a common practice in the early nineteenth century to keep separate the worts from the first and subsequent mashes. The first wort would obviously contain the greatest proportion of starch and went toward the brewing of the strongest beer; later mashes produced weaker beer. *Porter*, a hearty type of ale invented in England in the 1720s, was instead created from a mixture of successive (albeit strong) mashes. Lager beer brewers too, mixed the worts from different mashes. (H.S. Rich & Co. 1903:81-82; Ronnenberg 1993:64)



Left: A "modern" mash tun, pictured in Western Brewer *of June 1880. Right: A mid-nineteenth-century copper brew kettle, similar to that which Robert Portner would have used during the Civil War, from* One Hundred Years of Brewing.

Brewers experimented much with the mashing process. The Scots, for instance, devised a method called *sparging*, which involved a prolonged first mash followed by the sprinkling of water over the malt several times so as to remove the remaining starch. The heating of the mash tun by steam coils was a later innovation. Also important was the invention of the perforated *false bottom* for the tun, which allowed the introduction of water from below and the easy drainage of the wort to the brew kettle. Other practices, such as the addition of milled raw grain to the malt and the use of corn

and rice for quick and light infusions of starch were commonly taken up by American brewers by the turn of the twentieth century. By then, most brewers had also begun to drain off individual mashes and return them to the tun for mixing and reheating at various but precise temperatures. Such procedures could produce optimal and consistent results in terms of density or *specific gravity* that would produce beer with the desired balance of color, body and alcoholic content. (H.S. Rich & Co. 1903:78-79, 82-85)



Left: Section of a mid-nineteenth-century brew kettle with firebox and flue. Right: A similar, late nineteenth-century, closed brew kettle at the Tivoli-Union Brewery of Denver. Historic American Engineering Record, Library of Congress Prints and Photographs Division.

Drained from the mash tun to the brew kettle, the wort was ready for *brewing* or *boiling*. Boiling helped further break down and dissolve the malt starch in preparation for fermentation. It also served to reduce the wort to its proper strength through evaporation and to separate out some of the unwanted particles. Brew kettles or *coppers* varied in size, shape, and whether they were open or closed vessels depending on the scale of production and the traditions and predilections of the brewer. Until after the Civil War most brew kettles were made of copper and were heated from below by wood fires. They were commonly encased in brick structures that contained a furnace whose flue rose behind the copper. Fire brewing was eventually superseded by the use of steam coils as the heat source. Steam brewing was found to be more even, steadier, cleaner, and more

labor- and fuel-efficient, although some brewers long claimed that fire-brewed beer was superior.[1] (H.S. Rich & Co. 1903:87-89)

The wort was typically boiled for a time before the brewer added hops (*Humulus lupulus*). The female hop blossoms have at their base "a granular, resinous, bitter substance," lupulin, which imparts to beer its bitter flavor and certain preservative qualities. The addition of hops also serves to clarify the wort. Much debated was the question of the timing of the addition of hops. "Gradually the conviction became general that long boiling would extract the coarser tastes from the hops while dispelling the more volatile and finer ones, shorter time of boiling became more general, hops were added in several lots, and the finest flavored ones left to the last." (H.S. Rich & Co. 1903:55; Siebel and Schwarz 1933:91)

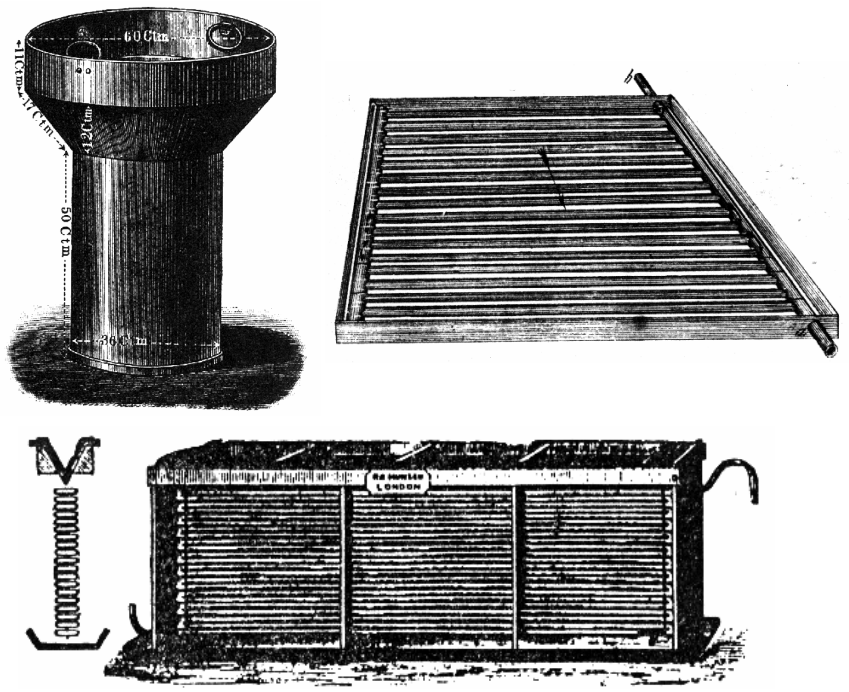
Boiling continued until the wort was completely "broken," that is, until unwanted particles had clumped together and the wort had clarified. This required about three hours on average, or between one and five hours. The wort was then drained through a *hopjack* that strained out the hop leaves. (H.S. Rich & Co. 1903:89; Ronnenberg 1993:64)

The hot wort had to be brought down to a temperature proper for the introduction of yeast and the beginning of fermentation. The earliest method was simply to allow the wort to cool slowly to atmospheric temperature in open tanks or *backs*. This took several hours, however, and could expose the wort to "wild" airborne yeasts and bacteria that could spoil its taste. As a result, brewers tried many alternatives to open cooling. The most widely adopted solution was to run the wort over pipes through which circulated ice water. A more sophisticated device based on this principle was invented by the Frenchman Jean-Louis Baudelot in 1856. Variations on Baudelot's invention were almost universally employed until ice water was replaced by other coolants, notably anhydrous ammonia and later, freon. (H.S. Rich & Co. 1903:91-92; Thevenot 1979:76)

Sufficiently cooled, the wort was ready for the fermenting tuns and the last step of manufacture, which would transform it to beer. *Fermentation* is the process of the conversion, by yeasts or other organisms, of sugar to alcohol and carbon dioxide. It provides beer with its mild alcoholic content and foamy head. Although it can certainly be said for the whole of the brewing process, the conduct of fermentation especially had always been more of an art than a science. Brewers kept and propagated yeast cultures for the purpose, but they had understood neither the nature nor agency in fermentation of the yeast organism. In fact, it was not until the research of Louis Pasteur and Emil Christian Hansen that pure yeast was isolated and the two main types of brewer's yeasts were identified. Pasteur's work on microbiology finally explained the previously inexplicable sourness of many a new batch of beer as resulting from exposure to "wild" yeasts and other microorganisms in the air. Before Dr. Hansen identified the brewer's yeasts, brewers found that individual yeast cultures acted differently, promoted different tastes, and performed their function best at divergent temperatures. Many brewers, including the English, fermented beer at temperatures between 55 and 65 degrees Fahrenheit. During the process, the yeast (*Saccharomyces cerevisiae*) would rise to the surface of the beer where it was skimmed off for future use. By the end of the eighteenth century, however, the Germans had cultivated a strain of yeast

[1] A Stroh's advertising campaign of the mid 1980s touted that brewery's "fire-brewed" beer.

(*Saccharomyces carlsbergensis*) that, at significantly lower temperatures, slightly above 40 degrees, would settle to the bottom of the tun and ferment the brew more slowly. Although American brewers had generally followed the English practice of top fermentation, bottom fermentation quickly caught on after the introduction of lager beer by German immigrants in 1840. (H.S. Rich & Co. 1903:96; Kelley 1965:444-445)



Wort cooling devices before artificial refrigeration.
Far left: attemperator or "swimmer." Left: Circa *1825 cooler which used ice water or brine. Images from* One Hundred Years of Brewing. *Lower left: Improved "Baudelot" cooler, post-1856,* pictured in The Western Brewer*, June 1880.*

The relatively higher temperatures at which the English-style beers could be fermented permitted their production at ambient atmospheric temperatures in most parts of Great Britain and the United States during much of the year. In contrast, lager beer, which became increasingly popular with each passing decade, needed a cooler environment in which to complete fermentation successfully. Brewers were generally restricted to operating in the colder months and, prior to the invention of artificial refrigeration, they used underground cellars and liberal amounts of ice to achieve and maintain the requisite temperatures. Beer cellars were made from modified natural caves, were excavated and constructed of masonry, or were cut out of solid rock. Subterranean cellars offered cool—but not freezing—temperatures and insulation. By the addition of natural ice to the cellar, brewers and their cellarmen could further lower the temperature. Only after the adoption of artificial refrigeration could brewers properly ferment their lagers above ground.

Generally, the fermentation of beer consists of three stages: the principal fermentation, in which the bulk of the malt sugar is converted to alcohol and carbonic acid; the secondary fermentation, during which carbon dioxide builds up and many impurities are eliminated; and the fining stage, in which the beer is finished, becoming clarified and fully "ripe." Primary fermentation was conducted in large vats called fermenting tuns. Open-top tuns were traditional for German brewers. These

vessels could be located inside or outside of the cellar. Fermenting tuns beyond the refrigerated environment of the beer cellar could be cooled by the introduction of *attemperators* or "swimmers." Attemperators were used prior to the use of artificial refrigeration and were essentially large metal buckets of ice that floated in the wort and cooled it by conduction. This principal fermentation of lager beer came to be conducted at 41 to 43 degrees Fahrenheit and would occur in three stages lasting a total of perhaps 25 to 30 hours. Upon completion of the primary fermentation, the beer was "racked over" into large *ruh*—or rest—casks for the secondary fermentation in the cellars, during which some of the yeast and other sediment would settle out, and the carbon dioxide content would increase. Freshly brewed wort was often added to beer during the secondary fermentation in order to "freshen" or invigorate it to create a more effervescent product. This process is called *kräusening*. These first two fermentation stages would generally take from seven to ten days total. Finally, the beer was transferred to another set of casks, the chip casks, for clarification or *fining* at a temperature of about 40 degrees. These casks were partially filled with beech or maple tree shavings to which unwanted particles, sediment, and leftover yeast would adhere. Fining by these "chips" was an American innovation of about 1860, although the Germans and English had previously used for clarification the gelatinous substance isinglass from the air bladders of sturgeon. Of course, a beer could be rushed and have essentially no aging, or it could be held for up to six months, in the case of some American lagers. (H.S. Rich & Co. 1903:98-102; Thevenot 1979:76; *Washington Post* March 13, 1898).

At the end of fermentation, rest, and aging the beer was finished. It could then be racked off into barrels or bottles for storage, sale or transport. Thereafter lager beer was kegged or bottled and was considered best when kept and served at around 40 degrees. Late nineteenth-century advances in bottle manufacturing, pasteurization, closures, and mechanized bottling speeded the preparation of beer for sale and made possible a much increased durability and broad distribution of a company's product. (Thomas 1887:17; see Chapter 7 for more information on technological innovation during the nineteenth century, and see Chapters 8 and 11 for more information on marketing and distribution)

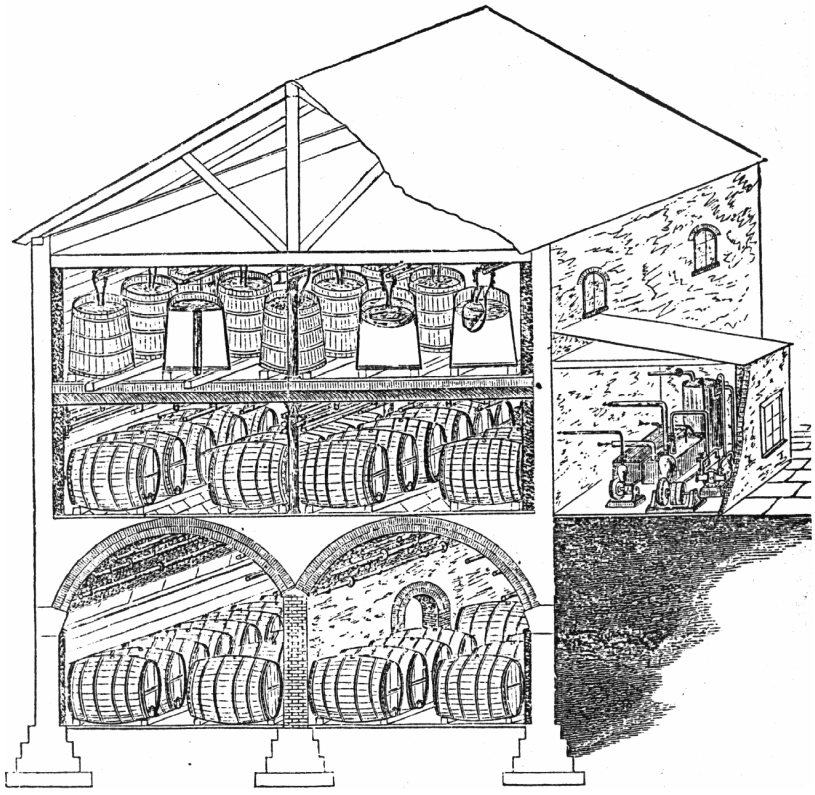
Clear and gold in color, somewhat dry and moderately hopped, lager is by far the most popular variety of beer in the world and has been for more than a century. The Philadelphian John Wagner was the first person known to brew lager in America, in 1840. From then on, most immigrant German brewers opened lager breweries. While lager consumption in America grew rapidly, it did not make serious inroads into the popularity of the English-style beers until the mid-1850s. By 1860 lager beer production still constituted less than one quarter of the total malt liquor production in the United States. During the Civil War, German soldiers' demand for beer encouraged the establishment of lager breweries, such as Portner & Company, even in the Southern states, and non-Germans were exposed to the new beer. (H.S. Rich & Co. 1903:207; Baron 1962:186; Ronnenberg 1993:12; Siebel and Schwarz 1933:57; Schlüter 1910:58)

When introduced to America, bottom-fermented beers were of two somewhat different types, winter beer and summer beer, named for the seasons in which the beer was ready for consumption. Summer beer was brewed in the coldest months of December, January and February, and for that reason was cooled to a lower temperature, and its fermentation was conducted more slowly than that of winter beer. Winter beer was produced in the comparatively warmer months of October,

November, March, and April. Technically, only summer beer was true lager. The distinction between summer and winter beer was soon obscured and forgotten in the U.S., however; bottom fermentation quickly became synonymous with lager beer. Thus, there are many varieties that are now made by the lagering process. (H.S. Rich & Co. 1903:100)

Ultimately, it was the introduction of artificial refrigeration that permitted year-round production of lager beer anywhere in the world and secured its universal popularity. The particular tastes of the American public have encouraged the production of beer that is much paler and more lightly hopped than that of the mid nineteenth century and with less alcohol, less sediment, and a more lasting head of foam. Since the late 1800s most American brewers have added rice and corn to their barley malt to provide a lighter golden color and a cheap, plentiful and quick source of fermentable starch suitable for use with American varieties of barley.

In addition to ales and lagers, some Alexandria brewers also produced *weiss* ("white") beer, a German variety made principally from wheat meal (the varieties of beer produced by Portner and other Alexandria brewers will be covered in more detail in Chapter 11).



Fermenting tuns, chip casks and aging casks in an ice house/cellar of the 1880s pictured in The Western Brewer. *Notice the compressor at the right; refrigeration systems such as this were one innovation of Robert Portner's (see Chapter 7).*